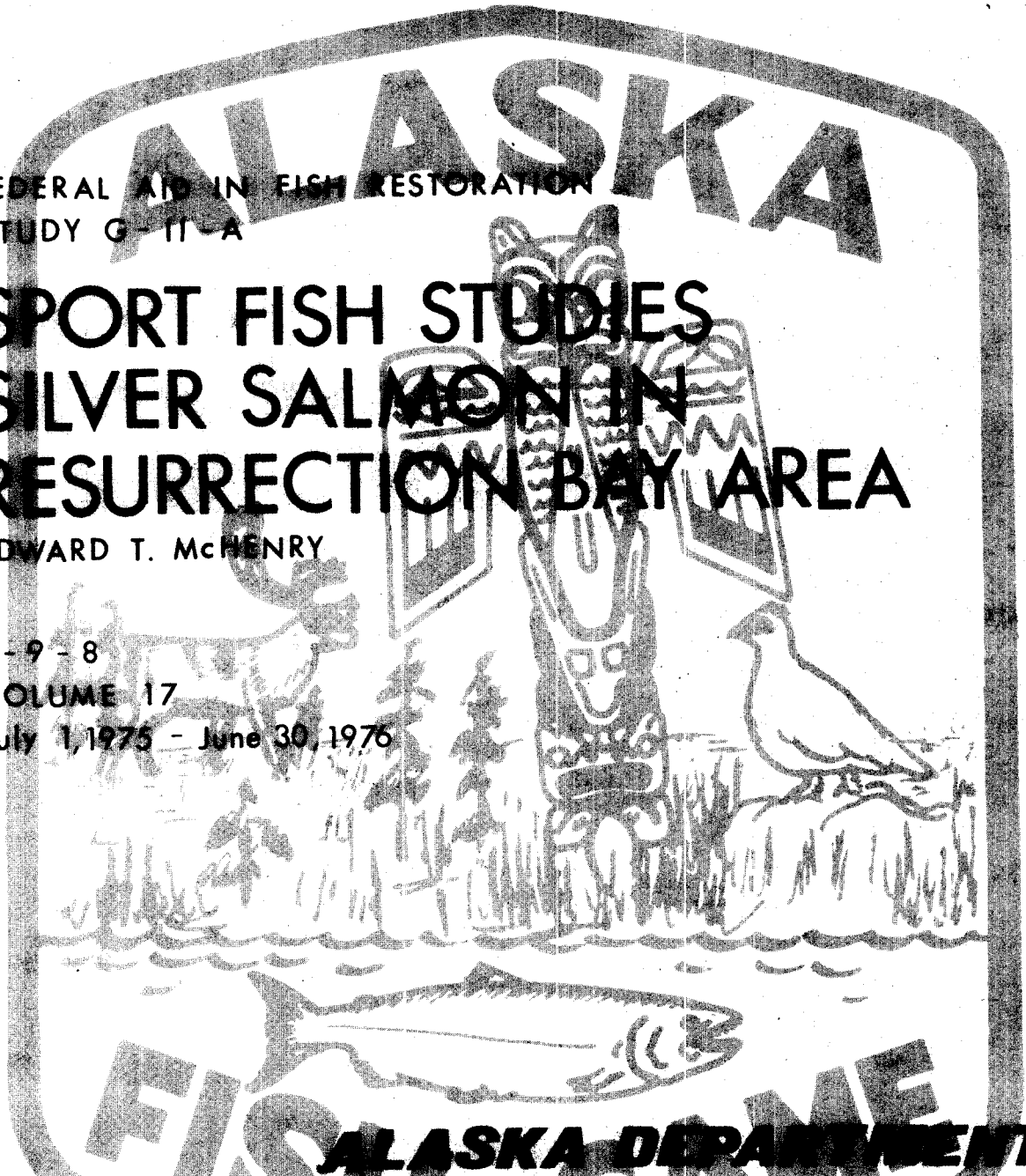
FEDERAL AID IN FISH RESTORATION
STUDY G-II-A

SPORT FISH STUDIES
SILVER SALMON IN RESURRECTION BAY AREA

EDWARD T. McHENRY

F-9-8
VOLUME 17
July 1, 1975 - June 30, 1976



ALASKA DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner
Sport Fish Division
Subport Building
JUNEAU, ALASKA

Volume 17 Study G-II-A

STATE OF ALASKA

Jay S. Hammond, Governor

Annual Performance Report for

SPORT FISH STUDIES
SILVER SALMON IN
RESURRECTION BAY AREA

by

Edward T. McHenry

ALASKA DEPARTMENT OF FISH AND GAME
James W. Brooks, Commissioner

SPORT FISH DIVISION
Rupert E. Andrews, Director
W. Michael Kaill, Chief, Sport Fish Research

TABLE OF CONTENTS

RESEARCH PROJECT SEGMENT

State:	ALASKA	Name:	Sport Fish Investigations of Alaska.
Project No.:	F-9-8		
Study No.:	G-II	Study Title:	SPORT FISH STUDIES
Job No.:	G-II-A	Job Title:	Silver Salmon Studies in the Resurrection Bay Area.

Period Covered: July 1, 1975 to June 30, 1976.

ABSTRACT

Project background (1961-1974) is briefly discussed.

Bear Lake was restocked with 450,000 age 0.0 coho salmon, Oncorhynchus kisutch, (Walbaum) fingerlings on June 19 and July 1, 1975 to maintain smolt production in the system.

The Bear Creek weir downstream migrant trap was operated continuously from May 20 through September 13. A total of 168,036 age 1.0, 2.0, and 3.0 coho smolts were enumerated. Smolt out-migration timing and abundance, age and size compositions, condition factors, Bear Creek mean water temperatures and stream flows are presented in this report. The decline in Bear Lake's age 1.0 smolt production due to overstocking at previous fingerling densities is reviewed.

The Resurrection Bay creel census (July 9 - September 7) indicated, that an estimated 19,793 coho were harvested in 20,047 man-days of effort. The mean seasonal catch per hour was 0.135 coho. Marked (fin-clipped) adult coho contributed 15.8% to the sport harvest. Most of these (71.6%) survived from the 100,000 age 1.0, hatchery reared, Ad-RV marked smolts planted in Seward Lagoon in May, 1974. Adult survival of age 1.0 and 2.0 Bear Lake smolts, Ad-Marked and released past Bear Creek weir in 1974 comprised 4.5% of the sport catch. Marked immature coho contributed an additional 12.5% to the harvest. These juveniles resulted from 100,000 age 1.0 hatchery reared Ad-Lv marked smolts stocked in Seward Lagoon in May, 1975.

The Bear Creek weir upstream migrant trap was operated continuously from May 16 to November 14. The adult coho upstream migration extended from September 8 to October 24, and peaked on September 25. The total migration consisted of 693 age 1.1 and 2.1 Ad-marked adults, 123 unmarked adults, 1 Ad-LV and 8 Ad-marked jacks. Marine survival of age 1.1 and 2.1 Bear Lake adults was 1.15% to the weir. The catch-to-escapement ratio of marked Bear

Lake adult coho was 1.28:1. Total smolt-to-adult survival of the 1974 Bear Lake smolt outmigration was 2.49%. The adult male-to-female sex ratio was 1.40:1. An estimated 887,700 fertilized eggs were artificially spawned from 237 females and 72 males. Average fecundity was 3,746 eggs per female.

Data on the timing and abundance of other fish species ascending and descending Bear Creek to the weir are presented. Minimum coho escapements in seven index streams are discussed.

BACKGROUND

Wild coho production in Resurrection Bay is believed to be directly affected by the extreme fluctuations in stream flows and water temperatures characteristic of the Bay's drainage streams. Since 1961 the Resurrection Bay coho sport fishery has been the largest marine sport fishery for salmon in Alaska. Therefore, there was a definite need to stabilize Resurrection Bay coho production to satisfy the rapidly growing angler demand, in this fishery.

Bear Lake, located seven miles north of Seward, was chosen for coho rearing enhancement because it is the largest (445 acres) stable body of fresh water in the Resurrection River drainage, and is accessible by road. It was determined after a survey in 1962 that Bear Lake should be rehabilitated with rotenone in 1963 to eradicate all predator and competitor fish species inhabiting the lake. Without coho predation and inter-specific competition, Bear Lake could produce a high sustained smolt yield from annual coho fingerling plants.

Pre-rehabilitation species abundances were measured by a temporary weir situated at the Bear Creek-Salmon Creek confluence during the years 1961 to 1964. Upstream migrations averaged 921 adult coho (1961-64); 4,801 adult sockeye, O. nerka (Walbaum), (1961-65); and 10,543 Dolly Varden char, Salvelinus malma (Walbaum), (1961-62). Downstream migration in 1962-1963 averaged 7,933 coho smolts, 51,232 sockeye smolts, and 17,838 Dolly Varden. Though threespine stickleback, Gasterosteus aculeatus Linnaeus, downstream migrations were not estimated at the weir, beach seine sampling indicated that this species is abundant in Bear Lake.

Bear Lake was rehabilitated with powdered rotenone at 1.0 ppm (5% level) on August 26, 1963. A 5-foot high dam was erected at the outlet to contain the treated water until detoxification and to prevent subsequent immigration of undesirable species into the lake. Bear Lake was detoxified by October 17, 52 days after the water was treated, and received its first annual fingerling plant that winter through the ice. All fingerling plants except the 1966 stocking were fin-marked at Fire Lake Hatchery to facilitate smolt survival evaluation.

The Good Friday earthquake on March 27, 1964 destroyed the outlet dam, which washed out completely on May 25. This allowed unobstructed entry of

all fish ascending Bear Creek into Bear Lake until June 15, when the barrier was repaired. A permanent weir was constructed 1,750 feet downstream from the outlet to assess Bear Lake's coho smolt production and returning adult migrations.

Bear Lake became reinfested with threespine sticklebacks; it is not known whether this was due to insufficient rotenone treatment or the destruction of the outlet barrier. Also, Dolly Varden were able to negotiate the weir during fall flood levels and immigrate into the lake during most years.

Before rapid expansion of the stickleback population occurred, Bear Lake's coho and sockeye smolt production increased several fold as a result of favorable rearing conditions from 1964 to 1966. Coho smolt biomass (weight) production attained 4.2 pounds for each pound of fingerlings planted in 1964. Smolt age structures changed from predominantly age 2.0 to age 1.0 with growth exceeding that of former age 2.0 smolts. Smolt survival from stocked coho fingerlings reached 43.5% and 48.1% of the 1964 and 1965 plants, respectively. Had sufficient coho fingerlings been available for stocking Bear Lake at desired densities in 1963-1965, coho smolt production undoubtedly would have been considerably higher. Bear Lake's enhanced smolt production increased pre-rehabilitation abundances of adult sockeye and coho by 11 and 3.5 fold, respectively, for one complete life cycle.

Bear Lake's high smolt production was short lived, however, due to the sticklebacks' rapid takeover of the rearing environment which began in 1967. Smolt age structures reverted to age 2.0 dominance, growth was diminished and fingerling-to-smolt survivals were lowered. Coho fingerling plants were terminated after 1967 because smolt production was obviously dropping below pre-rehabilitation levels. By 1968, threespine sticklebacks had already reached pre-rehabilitation abundance in the lake.

In 1969, it was decided to rehabilitate Bear Lake again. Stickleback population sampling in 1970 showed that this species inhabited all areas and depths in Bear Lake, thereby necessitating not only sufficient rotenone but that it be uniformly dispersed throughout the water column to assure a complete fish kill. Bear Creek weir was reconstructed in 1969 and made entirely fish-tight by removing the sloping upstream fence and adding three permanent, perforated plate screens immediately above the upstream migrant trap.

Bear Lake was rehabilitated again in 1971, and lake treatment was conducted essentially the same as in 1963 except that 100% emulsion instead of powdered rotenone was used. Overall treatment level was 1.6 ppm rotenone at 5% concentration. Caged live fish suspended from surface to bottom (40 and 60 feet) were all dead within one week. Population sampling two days following rehabilitation showed that threespine sticklebacks comprised 98.8% of the total sample (n=9, 065) collected randomly on and around Bear Lake. From this it was concluded that obtaining less than total lake rehabilitation in 1963 would ultimately result in lower than normal salmon production in Bear Lake over the long term.

Bear Lake remained toxic through the winter of 1971-72, and finally detoxified shortly after spring overturn. Annual coho fingerling plants in Bear Lake resumed in June, 1972 at desired stocking densities. Resultant smolts were enumerated, sampled weekly for age and size composition, and fin-marked for recognition in the fishery before being released at Bear Creek weir. No threespine sticklebacks have yet been detected in Bear Lake during fall population sampling by electrofishing or at Bear Creek weir since the 1971 rehabilitation.

RECOMMENDATIONS

1. Retain the present objectives of the study.

2. Continue to investigate the Resurrection Bay drainage for potential coho rearing pond sites.

3. Adjust the 1977 stocking density of coho fingerlings in Bear Lake according to emigrating smolt and residual fingerling abundance, age composition and condition factor in 1976.

OBJECTIVES

1. To determine the distribution, abundance, and timing of outmigrant and adult silver salmon in the Resurrection Bay area.

2. To determine the age and size composition of outmigrant and adult silver salmon populations in selected tributaries.

3. To determine the sport harvest and fishing mortality of silver salmon in Resurrection Bay.

4. To determine the methods and means of increasing or extending the freshwater spawning and rearing areas of the watershed, and mitigating freshwater mortality.

5. To provide recommendations for the management of silver salmon in these waters and direct the course of future studies.

TECHNIQUES

The timing and abundance of sockeye and coho smolts and coho fingerlings emigrating from Bear Lake downstream to Bear Creek weir were determined by enumerating these fish at the downstream migrant trap. Weir location and description of the downstream trapping facilities were presented by Logan (1969). The timing and abundance of jack sockeye (age 1.1) and adult coho were measured by enumerating these fish at the weir's upstream

migrant trap. Adult trapping facilities, rebuilt in 1969 and modified in 1970, were described by McHenry (1971). Bear Creek water temperatures and flows were recorded daily at the weir.

Age and size compositions of Bear Lake coho and sockeye smolt and residual coho populations were determined by weekly sampling at the weir and electrofishing in Bear Lake. Age structures of sockeye smolt and residual coho populations were determined by length-frequency analysis. Age composition of the coho smolt population was estimated by examining representative scale impressions on 0.02-inch cellulose acetate with a microprojector. Age structures of adult Resurrection Bay coho and Bear Lake sockeye populations also were determined by scale analysis. Age composition of the adult Bear Lake coho return was not sampled. Size compositions of Bear Lake's jack sockeye and coho escapements were determined by sampling most fish for fork length, weight, and sex. All fish sampled were anesthetized in a 1:20,000 solution of MS-222 to facilitate handling and minimize mortality.

Resurrection Bay coho sport harvest and angler effort were measured by a stratified, random creel census conducted at the Seward small boat harbor. Sampling design and interview method were nearly identical to that described by Logan (1966).

The average number and percentage of sport fishing boats returning to the Seward small boat harbor were determined for each of three 3.5-hour sampling periods extending from 11:30 a.m. to 10:00 p.m. Returning boats were not counted from 8:00 a.m. to 11:30 a.m. in 1975 because only 11.6% and 14.3% of the weekend and weekday sport craft, respectively, returned during this period in the three years sampled (1964-1966). The mean number of boats returning during this morning period was extrapolated using the above percentages. These estimates were then added to those determined for the three periods sampled to estimate total daily boats. Fishing mortality and catch-to-escapement ratio of marked (fin-clipped) adults were determined by examining as many coho as feasible during creel census and by recording marked coho in the Bear Lake and Seward Lagoon escapements.

An index to coho escapement abundance was measured by conducting periodic foot surveys on seven local index streams throughout immigration until peak of spawning terminated. All carcasses were examined for clipped fins, sexed, and mutilated to perclude recounting on subsequent surveys. A catch-to-escapement ratio was determined by comparing marked Bear Lake coho estimated in the sport harvest to those returning to Bear Creek weir.

Evaluation of the rehabilitated freshwater rearing environment in Bear Lake was continued by measuring the abundance, growth and condition of smolts surviving from the 1972, 1973, and 1974 coho fingerling plants.

FINDINGS

Results

The findings presented are the result of the 1974-1975 research segment of this project. For a description of the Resurrection Bay drainage and past information collected on the project, see Logan (1962-69), and McHenry (1970-1975).

Bear Lake Downstream Migration:

The Bear Creek weir downstream migrant trap was operated continuously from May 20 through September 13. The trap was removed on the latter date due to cessation of coho smolt, and fingerling migrations. Abundance and timing of those migrations are shown in Table 1. Fish were designated "smolts" on the basis of typical smolt characteristics (silvery pigment, loss of parr marks) rather than on size alone. If the fish did not possess these traits they were defined as "fingerlings", regardless of size.

The total smolt out-migration to the downstream trap and weir forebay was 168,036 fish. Trap and handling mortalities claimed 3,077 smolts (1.8% of the out-migration). An additional 21,370 smolts, or 12.7% of the run, died primarily from "eye fluke" disease caused by cercaria of Diplostomulum spathaceum (Grischkowksy, personal communication) in the forebay. A total of 143,589 smolts were released downstream. All smolts, except those previously marked in Bear Lake, received an adipose (Ad) fin-clip for recognition in the 1976 Resurrection Bay sport fishery and upon their return to Bear Creek. Smolt out-migration began on May 21, peaked (50% of migration) on June 27, and terminated September 12. The highest daily count occurred on June 26, when 11,438 (6.8% of the total run) were enumerated from the trap.

Mean stream temperatures when smolt out-migration began, peaked, and terminated were 1.7°C (35.0F), 9.7°C (49.5°F), and 11.7°C (53.0°F), respectively. Bear Creek stream flows ranged from 12 to 70 cfs during this period. Mean length, weight, and condition factor of all smolts sampled by weekly periods are shown in Table 2.

The fingerling downstream migration to the weir totaled 980 fish. Most appeared to be age 1.0 fingerlings from the 1974 plant, with a few age 0.0 fish observed at the weir after Bear Lake was restocked July 1. All fingerlings were retained above the weir. Trap mortality claimed 64 fish (6.5% of the migration). Timing and peak of the fingerling migration were similar to that of the smolt out-migration. Fingerlings were not sampled for fork length and weight at the weir because determination of smolt abundance was given priority.

The smolt out-migration was comprised of 8.0% (13,487) age 1.0, 91.4% (153,525) age 2.0, and 0.6% (1,024) age 3.0 smolts. Age composition and abundance were determined by extrapolating the relative percentages of

Table 1. Coho Salmon Smolts and Fingerlings Enumerated Through Bear Creek Weir by Weekly Periods, 1975.

Weekly Periods	Number of Smolts Live	Dead	Number of Fingerlings Live	Dead
5/20-5/26	41	10	4	1
5/27-6/ 2	270	5	10	0
6/ 3-6/ 9	4,916	13	31	2
6/10-6/16	19,096	89	248	3
6/17-6/23	38,797	115	298	3
6/24-6/30	41,902	111	121	3
7/ 1-7/ 7	26,852	1,745	114	0
7/ 8-7/14	7,499	4,190	38	6
7/15-7/21	1,878	5,901	16	1
7/22-7/28	1,350	5,998	15	14
7/29-8/ 4	679	4,211	7	6
8/ 5-8/11	93	878	2	2
8/12-8/18	0	512	0	1
8/19-8/25	39	416	12	0
8/26-9/ 1	27	78	0	1
9/ 2-9/ 8	0	0	0	0
9/ 9-9/15	150	175	0	21
Total	143,589	24,447	916	64

Table 2. Mean Fork Length, Weight, and Condition Factor of Bear Lake Coho Salmon Smolts Sampled Weekly at Bear Creek Weir, 1975.

Weekly Periods	Number Sampled	Mean Length (mm)	Mean Weight (g)	Condition Factor (K)*
5/20-5/26	29	145.1	24.08	0.79
5/27-6/ 2	100	139.5	22.36	0.82
6/ 3-6/ 9	100	137.3	21.45	0.83
6/10-6/16	100	133.3	21.33	0.90
6/17-6/23	100	130.8	20.02	0.89
6/24-6/30	100	128.0	18.94	0.90
7/ 1-7/ 7	100	126.3	18.38	0.91
7/ 8-7/14	100	124.4	16.70	0.87
7/15-7/21	100	129.2	19.14	0.88
7/22-7/28	100	130.0	20.83	0.95
7/29-8/ 4	100	130.3	20.53	0.93
8/ 5-8/11	100	131.2	19.31	0.86
8/19-8/25	39	139.1	26.43	0.98

* $K = \frac{Wx10^5}{L^3}$, where W = mean weight in grams, and L = mean fork length in

these age groups in biweekly scale sample analyses to the total number of smolts emigrating during those periods. Tables 3 and 4 show the mean fork length, weight, and condition factor of ages 1.0 and 2.0 smolts in the biweekly samples. Age 3.0 smolt sample sizes were not sufficient to warrant tabulating. Only one weekly period (8/19-25) was sampled after August 11 due to scarcity of smolts in the trap. Therefore, the age composition determined for that sample was applied to the remainder of the out-migration (1,397 smolts).

Table 3. Mean Fork Length, Weight and Condition Factor of Bear Lake Age 1.0 Coho Salmon Smolts Sampled Biweekly at Bear Creek Weir, 1975.

Biweekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm)	Mean Weight (g)	Condition Factor (k)
5/20-6/2	3	2.4	108.3	12.07	0.95
6/3-6/16	1	0.5	109.0	11.20	0.86
6/17-6/30	8	4.0	107.5	11.58	0.93
7/1-7/14	45	22.8	106.6	11.52	0.95
7/15-7/28	7	3.5	111.0	13.57	0.99
7/29-8/11	10	5.1	109.7	10.60	0.80
8/12-8/25	3	7.7	110.3	10.40	0.78

Table 4. Mean Fork Length, Weight and Condition Factor of Bear Lake Age 2.0 Coho Salmon Smolts Sampled Biweekly at Bear Creek Weir, 1975.

Biweekly Periods	Number of Smolts	Percent of Sample	Mean Length (mm)	Mean Weight (g)	Condition Factor (k)
5/20-6/2	120	95.2	141.4	22.78	0.81
6/3-6/16	193	98.0	135.0	21.23	0.86
6/17-6/30	191	96.0	130.3	19.83	0.90
7/1-7/14	150	76.2	130.7	19.28	0.86
7/15-7/28	190	95.5	130.1	20.09	0.91
7/29-8/11	187	94.4	131.9	20.40	0.89
8/12-8/25	34	87.2	140.8	27.68	0.99

The 1,024 age 3.0 smolts resulted from the initial 450,000 age 0.0 fingerlings stocked in Bear Lake after the 1971 lake rehabilitation. Bear Lake coho fingerling plants since the 1971 lake rehabilitation are summarized in Table 5 and subsequent smolt production is presented in Table 6. Total fingerling-to-smolt survival for the 1972 plant was 19.3%. Age composition of the first Bear Lake smolt production cycle was 89.3% age 1.0, 9.5% age 2.0, and 1.2% age 3.0. The 153,525 age 2.0 smolts were produced from 443,300 age 0.0 fingerlings planted in Bear Lake in 1973, and with the 64,119 age 1.0 smolts in 1974 represent a phenomenal 49.1% fingerling-to-smolt survival thus far. Few additional age 3.0 smolts surviving from this plant are expected in 1976, however, according to population sampling of Bear Lake's residual coho in October, 1975, only 1.0% of the sample (n=506) were age 2.0 fish, according to the length-frequency analysis. Residual coho population samples by electrofishing are shown in Table 7. Except for the few age 3.0 smolts anticipated in 1976, age composition of Bear Lake's second smolt production cycle was 29.5% age 1.0 and 70.5% age 2.0. The 13,487 age 1.0 smolts resulted from the third annual Bear Lake plant of 450,800 age 0.0 fingerlings in 1974. Fingerling-to-smolt survival of this age group was only 3.0%. The aforementioned population sampling in Bear Lake showed that only 9.5% were age 1.0 fish in 1975; therefore, age 2.0 smolts in 1976 likely will be similarly scarce.

Table 5. Summary of Bear Lake Coho Salmon Fingerling Plants Since the 1971 Lake Rehabilitation Program.

Brood Year	Source of Eggs	Number of Fish	Weight		Size		Density		Dates of Plants	Planting Method
			lbs.	kg	No./lb.	No./kg	No./acre	No./Ha		
1971	Bear Lake	450,000	522	237.0	862	1,898	1,011	2,499	June 26,27	Truck at lake outlet
1972	Bear Lake	96,900	113	51.3	857	1,889	218	538	June 19	Truck-boat
	Lake Rose Tead	346,400	538	244.2	644	1,418	778	1,923	June 20	Scattered
	Total	443,300	651	295.5	681	1,500	996	2,461		
1973	Upper Station	240,900	476	216.1	506	1,115	541	1,338	July 15	Truck-boat
	Upper Station	200,900	416	188.9	483	1,063	452	1,115	July 16	Scattered
	Upper Station	9,000	29	13.1	310	678	20	50	July 16	
	Total	450,800	921	418.1	489	1,078	1,013	2,503		
1974	Bear Lake	245,600	454	206.1	541	1,192	552	1,364	June 19	Aircraft
	Bear Lake	204,400	455	206.6	449	989	459	1,135	July 1	Scattered
	Total	450,000	909	412.7	495	1,090	1,011	2,499		

Table 6. Summary of Bear Lake Coho Salmon Smolts and Biomass (kg) Produced From Annual Fingerling Plants Since the 1971 Lake Rehabilitation Program.

Year of Plant	Number and Weight (kg) planted	Smolt Production by Year (age group) 1973	1974	1975	Total Production	Survival to Smolt Percent
1972						
Number	450,000	77,343	8,270	1,024	86,637	19.3
Weight (kg)	237.0	2,109.1	287.2	29.4	2,425.7	
Weight Ratio		8.9:1	1.2:1	0.1:1	10.2:1	
1973						
Number	443,300		64,119	153,525	217,644	49.1(1)
Weight (kg)	295.5		1,462.2	3,182.6	4,644.8	
Weight Ratio			4.9:1	10.8:1	15.7:1(1)	
1974						
Number	450,800			13,487		
Weight (kg)	418.1			155.9		
Weight Ratio				0.4:1		
1975						
Number	450,000					
Weight (kg)	412.7					

(1) Data is minimal because it does not include age 3.0 smolts.

Table 7. Age Composition of Bear Lake Residual Coho Populations Sampled By Electrofishing in October, 1972-1975. (Mean Fork Length Per Age Group in mm Shown in Parentheses).

Sampling Year	No. Fish Sampled	Age Composition (%)*			
		0.0	1.0	2.0	3.0
1972	105	100.0 (76.6)			
1973	349	75.4 (88.1)	24.6 (131.2)		
1974	325	40.9 (73.4)	52.3 (124.4)	6.8 (163.8)	
1975	506	86.4 (77.0)	9.5 (114.7)	1.0 (159.6)	3.1** (192.0)

* Determined by age group separation points in length-frequency analyses.
** Comprised of sexually mature males attemting to spawn.

A total of 1,363 Ad-marked smolts were recaptured in the downstream trap. These fish survived from the 2,416 age 0.0 and 1.0 fingerlings captured by electrofishing in Bear Lake and Ad-clipped for a population estimation experiment in mid-October, 1973. Though these smolts were not sampled for age, the age 2.0 and 3.0 composition was probably similar to that of the unmarked smolts. With the 411 age 1.0 and 2.0 Ad smolts recaptured in 1974, a total of 1,744 fish (73.4%) survived the marking experiment to emigrate as smolts.

Migration timing differed slightly between age 1.0 and 2.0 smolts. Age 2.0 smolts peaked during June 24 to 30 while age 1.0 smolts peaked one week later, July 1 to 7. Age 3.0 smolts also peaked in the latter weekly period. Over-all smolt mortality (14.5% of the out-migration) was considered in portion to the smolt population age composition. Therefore, an estimated 11,487 age 1.0, 131,240 age 2.0, and 862 age 3.0 smolts were released downstream after mortality.

Smolt growth declined substantially from that observed during 1973 and 1974. Though age 1.0 smolts were essentially the same size at the migration peak in both 1973 (107.5 mm) and 1975 (107.3 mm), growth as the summer progressed was almost nil in 1975 (Table 3). By contrast, age 1.0 smolts increased 63.4 mm and 47.8 mm in fork length from migration peak to mid-September in 1973 and 1974, respectively. Age 2.0 smolts averaged 147.6 mm at migration peak in 1974, and grew 49.6 mm in fork length by mid-September.

In 1975, however, age 2.0 smolts increased only 11.6 mm mean fork length from migration peak to mid-August (Table 4). It is noted that age composition of the 1974 out-migration was determined by length-frequency separation instead of by the scale analysis method that was used 1975. Therefore, mean lengths per age group in 1974 may not be as accurate as those for 1975 age groups, but are believed to be comparable.

Despite the large increase (92.5%) in total smolt biomass produced in 1975 due to the aforementioned age 2.0 age smolt survival, Bear Lake's smolt productivity is still declining (Table 6). Multiplying the seasonal mean smolt weight per age group by the total smolts emigrating yielded 3,367.9 kg in 1975, compared to 1,749.4 kg in 1974. The decline in smolt productivity becomes evident, however, upon examining the ratio of the age 1.0 smolt biomass yield per annual fingerling plant biomass. In 1973, the ratio was 8.9 kg of age 1.0 smolts produced for each kg of age 0.0 fingerlings stocked. In 1974 and 1975, the ratios were 4.9:1 and 0.4:1, respectively. This shows an abrupt decline in three years from almost nine times to less than one-half the stocked fingerling weight resulting in age 1.0 smolts.

Population sampling in Bear Lake indicated that its residual fingerling population still was fairly abundant despite the massive age 2.0 smolt emigration earlier in 1975. Electrofishing the littoral zone along Bear Lake's southern shoreline on October 7, two shocker units captured 1,633 coho fingerlings in 3.2 hours (510 fish/hour). This catch rate compares favorably with 462 and 645 fish/hour realized in 1973 and 1974 respectively, and may reflect a similar degree of relative fingerling abundance in 1975.

Length-frequency analysis of the 1975 population subsample showed that juvenile age dominance reverted to age 0.0 fingerlings (Table 7). Age 3.0 residuals in 1975 were comprised of sexually mature males attempting to spawn along the beach. Average size of age 0.0 fingerlings increased slightly (3.6 mm) over that of the same age group in 1974, probably due to the increased rearing area vacated by the 1975 age 2.0 smolt out-migration. Mean fork length for age 1.0 and 2.0 fish, however, decreased 9.7 mm and 4.2 mm, respectively, suggesting that intense intraspecific competition from overstocking limited their growth in 1974 and 1975.

Other Species:

The total sockeye salmon, O. nerka (Walbaum), smolt out-migration enumerated from the trap was 4,959 fish. Trap and disease mortalities claimed 263 smolts, or 5.3% of the downstream migration. The first smolt was captured on June 7, and the last on August 27. The highest daily count occurred on July 5 when 1,814 smolts (36.6% of the migration) were enumerated. The majority (95.3%) of these smolts emigrated between July 1 and 31, when water temperatures ranged from 3.3° to 12.2°C (38-54°F), and stream flows from 41-70 cfs. The smolt out-migration was comprised of 3,915 (78.9%) age 2.0 and 1,044 (21.1%) age 1.0 smolts. Age 2.0 smolts were produced by the 390 females and 331 males that spawned in Bear Lake in 1972. Including the 4,402 age 1.0 smolts emigrating in 1974, total smolt production was 9,361 smolts (24.0 per female) for the first, post-rehabilitation sockeye.

escapement in 1972. Age 1.0 smolts resulted from the 1973 escapement of 145 females and 91 males, averaging 7.2 smolts per female. At peak of migration (July 8 to 14) age 2.0 smolts averaged 149.7 mm in fork length with a condition factor of 0.89. Age 1.0 smolts had a mean fork length of 104.4 mm and a condition factor of 0.90 during the same period. Age 1.0 smolts in 1974 averaged 109.3 mm in fork length with a condition factor of 1.00 at migration peak.

A total of 93 Dolly Varden, were captured in the downstream trap. No threespine stickleback were captured in the trap nor observed while electrofishing Bear Lake.

Resurrection Bay Coho Harvest and Effort:

A stratified, random creel census to determine the Resurrection Bay coho sport harvest and effort was initiated at the Seward small boat harbor on July 9 and terminated September 7. Compared to previous years, coho were taken in fair abundance about two weeks prior to the creel census. Due to the priority of Bear Lake smolt processing, however, the creel census was necessarily delayed until the normal starting date.

The season's total harvest was estimated at 19,793 coho. This estimate was extrapolated from interviews with 4,224 anglers who harvested 3,795 coho during the creel census period. Peak of the harvest occurred on August 10, second day of the Seward Silver Salmon Derby, when an estimated 892 fish (4.5% of the season's harvest) were taken. The season's total and derby harvests are summarized for 1971 through 1975 in Table 8. The conspicuous drop in the 1975 derby harvest was due to low angler participation.

The total sport fishing effort exerted for Resurrection Bay coho was estimated to be 20,047 man-days. Approximately 21% of the season's effort was sampled during the creel census period. Sport fishing effort was calculated by multiplying the total number of boats by the average number of anglers per boat. Total boats returning daily to the Seward small boat harbor are shown in Table 9. The average numbers of anglers per boat were as follows: weekdays - 3.30, weekends - 3.37, and salmon derby - 3.32. Fishing effort and mean catch per hour from 1971-1975 are summarized in Table 10. The fishing effort was 8.064 man-days on weekdays 6,112 on weekends excluding the derby. Military personnel and dependents, from boats provided by the Army and Air Force recreation camps at Seward, contributed 19.0% (3,804 man-days) of the total effort.

Table 8. Derby and Total Sport Harvests of Coho Salmon in Resurrection Bay, 1971-1975.

Year	Total Sport Harvest	Derby Harvest	% Derby Harvest
1971	20,593	9,488	46.1
1972	15,236	4,755	31.2
1973	13,911	4,334	31.2
1974	18,629	5,646	30.3
1975	19,793	3,799	19.2

Table 9. The Mean Number and Percentage of Sport Fishing Boats Returning to the Seward Small Boat Harbor During Each Sampling Period, 1975.

Periods (hours)	Weekends		Weekdays	
	Mean No. of Boats	Percent	Mean No. of Boats	Percent
8:00 a.m.-11:30 a.m.*	9.6	11.6	5.9	14.2
11:30 a.m.- 3:30 p.m.	21.9	26.4	8.0	19.3
3:00 p.m.- 6:30 p.m.	36.8	44.3	18.6	44.8
6:30 p.m.-10:00 p.m.	14.7	17.7	9.0	21.7
Total	83.0	100.0	41.5	100.0

* Percentage for this period determined by three-year mean, 1964-1966.

Table 10. Derby and Total Sport Effort (Man-days) Exerted for Coho Salmon and Mean Catch Per Hour in Resurrection Bay, 1971-1975.

Year	Period of Census	Total Effort	Derby Effort	% Derby Effort	Catch Per Hour
1971	7/12-9/8	26,485	12,988	49.0	0.112
1972	7/4-9/10	30,124	12,850	42.7	0.079
1973	7/7-9/9	24,301	9,885	40.7	0.095
1974	7/2-9/9	25,902	10,225	39.5	0.109
1975	7/9-9/7	20,047	5,871	29.3	0.135

The seasonal mean catch per hour was 0.135 coho. Civilian anglers fishing on weekdays realized the highest catch per hour (0.206 fish) whereas the lowest catch rate (0.090 fish) occurred during the derby when effort was greatest. The average numbers of hours anglers fished per day were as follows: weekdays - 6.34, weekends - 6.16, and salmon derby - 7.17.

Examination of 250 scale samples randomly collected throughout the sport fishery disclosed that the wild coho population was comprised of 58.0% age 1.1, 35.2% age 2.1, and 6.8% age 3.1 adults. Mean fork lengths and weights of wild fish are presented in Table 11. The male-to-female sex ratio was 2.0:1 in the fishery.

Table 11. Mean Fork Length (mm) and Weight (kg) of Wild Adult Coho Salmon, Sampled from the 1975 Resurrection Bay Sport Fishery.

	Number of Fish	Mean Length (mm)	Number of Fish	Mean Weight (kg)
Males	169	662.9	166	4.25
Females	83	660.7	78	4.06
Total	252	662.2	244	4.19

Chinook, O.tshawytscha, (Walbaum) and pink salmon, O. gorbuscha, (Walbaum) were taken incidentally with coho during the season. An estimated 537 chinook salmon were harvested during the census period at an average rate of 0.11 fish per boat. This species was most abundant in late August when anglers averaged 0.24 fish per boat. Most chinook salmon taken were immature fish in their first and second ocean-years. Origins of these stocks are unknown as chinook salmon rarely ascend Resurrection Bay streams. Though pink salmon were in their normally low, odd-year cycle, they were unusually abundant (0.61 fish per boat) in the 1975 sport fishery. The total pink salmon sport harvest was an estimated 2,582 fish, only 202 less than the 1974 catch. This species was most abundant in late July when anglers averaged 1.24 fish per boat. These stocks evidently were bound for systems elsewhere, since Resurrection Bay streams had typically poor, odd-year spawning escapements in 1975.

Bear Lake Upstream Migration:

The Bear Creek Weir upstream migrant trap was operated continuously from May 16 to November 14. The first Coho entered the trap on September 8 and the last one was captured October 24. No additional fish were observed below the weir in November due to early freeze-up and rapid icing over.

A total of 825 coho, including nine jacks, were enumerated from the trap. Abundance and timing of the adult coho migration are shown in Table 12. The migration peaked on September 25, and the highest daily count of 68 fish (8.2% of the run) occurred on September 30. Mean stream temperatures at the beginning, peak, and end of migration were 11.4°C (52.5°F), 10.6°C (51.0°F) and 5.0°C (41.0°F). Most of the migration (83.9%) occurred from September 9 through October 6 when Bear Creek temperatures ranged from 7.8% - 11.7°C (46°-53°F) and flows, from 15-80 cfs.

All returning adults probably resulted from the 1974 out-migration of 70,765 age 1.0 and 2.0 Bear Lake smolts released past the weir. Scale sampling for age composition analysis was not conducted on these fish because some adults could have resulted from natural smolt production below the weir in 1974. It would not have been possible to differentiate between the latter and unmarked Bear Lake coho by scale examination. Therefore, relative smolt-to-adult survivals of age 1.0 versus age 2.0 smolts are not known. Since it is assumed that all returning adults resulted from Bear Lake smolts, marine survival of the 1974 smolt out-migration was 1.15% as spawning escapement to the weir. The catch-to-escapement ratio of marked Bear Lake adult coho was 1.28:1.

Eight Ad-marked jacks enumerated from the trap returned prematurely from the 1975 Bear Lake smolt out-migration. One Ad-LV jack captured at Bear Creek weir strayed from Seward Lagoon where it was released as a marked, hatchery-reared smolt in May, 1975. In 1974, four marked jacks from Seward Lagoon accompanied the Bear Creek coho escapement to the weir.

Table 12. Bear Lake Adult Coho Salmon Enumerated Through Bear Creek Weir By Weekly Periods, 1975.

Weekly Periods	Ad	Unmarked*	Male	Female	Total
9/2-9/8	1		1		1
9/9-9/15	120	16	87	49	136
9/16-9/22	186	29	130	85	215
9/23-9/29	128	25	90	63	153
9/30-10/6	158	30	100	88	188
10/7-10/13	22	13	20	15	35
10/14-10/20	73	10	47	36	83
10/21-10/27	5		1	4	5
Total	693	123	476	340	816

*Returns from smolts inadvertently released unmarked in 1974.

Part of the Department's coho egg requirements for the Southcentral Alaska region were obtained from the Bear Lake return. A total of 287 males and 330 females were held to ripen in the Bear Creek holding facility from September 11 to November 12. Stream temperatures ranged from 0°-12.2°C (32°-54°F) during this period. Male and female holding mortalities were 24.0 and 23.9%, respectively. A total of 237 females and 72 males were artificially spawned, yielding an estimated 887,700 fertilized eggs. Mean fecundity was 3,746 eggs per female. Eggs were fertilized at an average ratio of 1 male:3.3 females. Dead egg loss after shocking at Fire Lake Hatchery averaged 6.0% (Wallis, personal communication).

Mean fork lengths of adult coho measured at the weir were 695.0 mm (n=71) and 660.3 mm (n=421) for males and females, respectively. The male-to-female sex ratio, excluding jacks, was 1.4:1 in the Bear Lake escapement. Fifteen females and 201 males were released upstream to spawn in Bear Lake tributaries. All spawned carcasses were deposited in Bear Lake for natural fertilization.

Other Species:

A total of seven sockeye jacks were captured in the upstream trap from June 30 to July 23. All were scale sampled for age analysis, and subsequently determined age 1.1. These fish resulted from the out-migration of 4,402 age 1.0 Bear Lake sockeye smolts in 1974. Age 1.2 adults are expected to return in 1976 from this smolt out-migration.

Upstream migrant Dolly Varden ascended Bear Creek to the weir in early July and continued moving in and out of the trap throughout the remaining field season.

One adult steelhead trout, Salmo gairderi, entered the upstream trap on September 25. The small male measured approximately 560 mm in fork length. Though formerly common in the Bear Lake system until the late 1950's, this species has rarely been observed in Bear Creek in recent years.

All fish other than sockeye or coho salmon were retained below the weir.

Adult Coho Timing and Abundance in Index Streams:

Peak of the 1975 index escapements was in late October and peak of spawning generally occurred within the following two weeks. Minimum coho escapements in each stream index area since 1971 are presented in Table 13. The period from 1972 to 1975 encompasses one complete life cycle, which is typically four years (age 2.1) for Resurrection Bay coho.

Table 13. Minimum Coho Salmon Escapement in Seven Index Streams in the Resurrection Bay Area, 1971-1975.

Name of Stream	Minimum Escapement					Mean
	1971	1972	1973	1974	1975	1971-74
Airport	13	15	4	23	2	14
Box Canyon	56*	59	36	28	8	45
Clear	93	55	37	60	15	61
Dairy	46*	49*	63*	114*	32*	68
Grouse	150	42	34	64	12	72
Jap	79	68	40	77	31	66
Mayor	19	22	4	51	5	24
Total	456	310	218	417	105	350

*Does not include marked jacks or adults returning from hatchery-reared smolt releases.

The total combined index escapement of 105 adults is the lowest observed in the 15 years monitored, and only 23% as large as the 1971 parent brood escapement that mainly produced it. Though little correlation exists between percentage of index escapement to projected total Resurrection Bay coho escapement (fluctuated from 1.0%-11.5% since 1963), index counts will be maintained to investigate possible relationship of previous years' climatic factors to subsequent adult production in these streams.

Fin Marked Coho Returns:

Marked age 1.1 and 2.1 adults contributed 15.8%, or an estimated 3.126 fish, to the 1975 Resurrection Bay sport harvest. These fish mainly resulted from 100,000 age 1.0 (1872 brood, Lake Rose Tead, Kodiak origin) hatchery reared and Ad-RV marked smolts stocked in Seward Lagoon in May, 1974. Adult survival of these smolts contributed an estimated 2,237 coho (11.3%) to the season's sport catch. An additional 889 Ad-marked coho contributed 4.5% to the sport harvest. These fish returned from 70,765 age 1.0 and 2.0 Bear Lake smolts marked and released past Bear Creek weir in 1974.

Marked coho spawning escapements bound for Seward Lagoon and Bear Creek were 1,648 and 750 adults, respectively. These escapements include 1,484 Ad-RV and 57 Ad fish estimated taken in the shore fishery after the Resurrection Bay sport trolling season terminated. Total smolt-to-adult survival for the Seward Lagoon coho, including 4,764 age 1.0 immatures and jacks caught in 1974, was 8.6%. Smolt-to-adult survival of Bear Lake smolts, including 123 unmarked adults in the 1975 Bear Creek escapement, was 2.5%. The overall catch-to-escapement ratio of marked Seward Lagoon and Bear Lake adult coho was 1.30:1.

In addition to the marked adult catch, an estimated 2,502 marked immatures and jacks contributed 12.6% to the sport harvest. These fish resulted from 100,000 age 1.0 (1973 brood, Bear Lake origin) hatchery reared, Ad-LV marked smolts stocked in Seward Lagoon from May 5-19, 1975. Including the 57 age 1.0 jacks (53 estimated taken in the shore fishery) in the lagoon escapement, total Ad-LV smolt survival thus far was 2.6%. Age 1.1 adults surviving this smolt plant will return in 1976. The total marked coho contribution to the Resurrection Bay fishery, including adult and immature fish, was 28.4%.

Discussion

Bear Lake has been stocked with coho annually since the 1971 lake rehabilitation at densities ranging from 996 to 1,013 fingerlings per surface acre. The cumulative effect in just three years resulted in overstocking Bear Lake's coho rearing habitat. Intense intraspecific competition among fingerlings evidently caused depressed growth rates and, consequently, extended rearing to attain smoltification. As a result, the percentage of successive fingerling plants surviving to age 1.0 smolts declined abruptly. A further manifestation of Bear Lake's overcrowded coho population was an apparently greater susceptibility of rearing fingerlings to natural diseases, primarily eye flukes, in 1975. Increased stress resulting in poor condition and high

incidence of disease epizootics in fish populations is well documented.

A downward adjustment in Bear Lake's coho stocking density is therefore clearly indicated. Bear Lake will be stocked in 1976 at only 500 fingerlings per acre, or approximately one-half previous densities, to enhance growth and survival to smolts.

It is theorized at this point (i.e., with the limited smolt production data obtained thus far) that stocking Bear Lake alternately at high then low fingerling densities may ultimately result in a maximum sustained yield of age 1.0 smolts each year. This practice, however, must eventually be compared with stocking at a constant, intermediate density to determine which method will maintain the greatest inventory of age 0.0 fingerlings at an optimal growth rate to reach age 1.0 smolt stage the following spring. Population sampling by electrofishing Bear Lake's southeastern shore each fall will be continued to evaluate relative survival and growth of the current year's plant and to tentatively determine the suitable stocking level for the following year.

LITERATURE CITED

Logan, S.M. 1962. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1961-1962, Project F-5-R-3, 3:57-74.

_____. 1963. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1962-1963, Project F-5-R-4, 4:175-194.

_____. 1964. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1963-1964, Project F-5-R-5, 6:133-151.

_____. 1965. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1964-1965, Project F-5-R-6, 6:129-145.

_____. 1966. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1965-1966, Project F-5-R-7, 7:79-99.

_____. 1967. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1966-1967, Project F-5-R-8, 8:83-102.

_____. 1968. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1967-1968, Project F-5-R-9, 9:117-134.

_____. 1969. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1968-1969, Project F-9-1, 10:131-149.

McHenry, E.T. 1970. Silver salmon studies in the Ressurection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Profect F-9-2, 11:75-89.

_____. 1971. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12:1-20.

_____. 1972. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1971-1972, Project F-9-4, 13:1-20.

_____. 1973. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1972-1973, Project F-9-5, 14:1-22.

_____. 1974. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6, 15:1-19.

_____. 1975. Silver salmon studies in the Resurrection Bay area. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1974-1975, Project F-9-7, 16:1-21.

Prepared by:

Edward T. McHenry
Fishery Biologist

Approved by:

s/Wm. Michael Kaill, Chief
Sport Fish Research

s/Rupert E. Andrews, Director
Sport Fish Division